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Center for Electronics and Electrical Engineering

Technical Publication Announcements

Covering Center Programs,
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INTRODUCTION TO THE CEEE TECHNICAL PUBLICATION ANNOUNCEMENTS

This is the thirteenth issue of a quarterly publication providing information on the technical work of the National Bureau of Standards Center for Electronics and Electrical Engineering. This issue of the CEEE Technical Publication Announcements covers the second quarter of calendar year 1987.

Organization of Bulletin: This issue contains citations and abstracts for Center papers published in the quarter. Entries are arranged by technical topic as identified in the table of contents and alphabetically by first author within each topic. Following each abstract is the name and telephone number of the individual to contact for more information on the topic (usually the first author). This issue also includes a calendar of Center conferences and workshops planned for calendar year 1987, some preliminary events for 1988, and a list of sponsors of the work.

Center for Electronics and Electrical Engineering: Center programs provide national reference standards, measurement methods, supporting theory and data, and traceability to national standards.

The metrological products of these programs aid economic growth by promoting equity and efficiency in the marketplace, by removing metrological barriers to improved productivity and innovation, by increasing U.S. competitiveness in international markets through facilitation of compliance with international agreements, and by providing technical bases for the development of voluntary standards for domestic and international trade. These metrological products also aid in the development of rational regulatory policy and promote efficient functioning of technical programs of the Government.

The work of the Center is divided into two major programs: the Semiconductor Technology Program, carried out by the Semiconductor Electronics Division in Gaithersburg, MD, and the Signals and Systems Metrology Program, carried out by the Electrosystems Division in Gaithersburg and the Electromagnetic Fields and Electromagnetic Technology Divisions in Boulder, CO. See the table of contents on the opposite page for identification of the topics covered by each program, as represented in this issue. Key contacts in the Center are given on the back cover; readers are encouraged to contact any of these individuals for further information.

Center sponsors: The Center Programs are sponsored by the National Bureau of Standards and a number of other organizations, in both the Federal and private sectors; these are identified on page 20.

Note on Publication Lists: Guides to earlier as well as recent work are the publication lists covering the work of each division. These lists are revised and reissued on an approximately annual basis and are available from the originating division. The current set is identified in the Additional Information section, page 18.

National Bureau of Standards
Gaithersburg, Maryland 20899

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SEMICONDUCTOR TECHNOLOGY

Silicon Materials

Hyland, S.L., Ast, P.G., and Baghdadi, A., **Oxygen Measurements in Thin Ribbon Silicon**, Journal of Crystal Growth (Proceedings of the First International Symposium on Shaped Crystal Growth, Budapest, Hungary, July 22-25, 1986), Vol. 82, Nos. (1/2), pp. 191-196 (North Holland, Amsterdam, 1987).

The oxygen content of thin silicon ribbons grown by the dendritic web technique was measured using a modification of the ASTM method based on Fourier transform infrared spectroscopy. Web silicon was found to have a high oxygen content, ranging from 13 to 19 ppma, calculated using the new ASTM conversion coefficient. The oxygen concentration changed by about 10% along the growth direction of the ribbon. In some samples, a shoulder was detected on the absorption peak associated with interstitial oxygen. A similar shoulder in Czochralski-grown material has been variously interpreted in the literature as due to a complex of silicon, oxygen, and vacancies, or to a phase of SiO_2 developed along dislocations in the material. In the case of web silicon, it is not clear which is the correct interpretation of this peak.
[Contact: Aslan Baghdadi, (301) 975-2062]

Mayo, S., and Lowney, J.R., **Photoionization Cross-Section Studies of the Platinum-Donor Center in Silicon**, Journal of Applied Physics, Vol. 61, No. 7, pp. 2626-2632 (1 April 1987).

The relative photoionization cross section of the platinum donor center in silicon was measured over the wavelength range of 2.4 to 3.9 μm by electrical deep-level optical spectroscopy (DLOS) on an n^+p junction at 80 K. The data were analyzed in terms of the lattice-coupling model proposed by Ridley and Amato, which was modified for valence band nonparabolicity. Good agreement was obtained between the experimental results and the model calculations of the cross section with the energy level of the donor at 0.320 ± 0.005 eV above the valence band edge and a Huang-Rhys factor S of approximately 1.4. This S-value corresponds to a Franck-Condon energy shift of 70 meV with a phonon energy of 50 meV. Previously reported photoionization data of the gold donor were also fit by the same model yielding $S \simeq 0.4$, a surprisingly small value. Estimates were made of the majority carrier capture cross section for these two levels and for the platinum acceptor center in silicon which was measured previously. These estimates, based on Ridley's quantum defect model and our measured S-values, are several orders of magnitude smaller than the corresponding measured values, indicative of the complex nature of these 5d-transition elements in silicon. More elaborate models, perhaps including anharmonicity of the defect vibrations, are required to understand these large capture cross sections.
[Contact: Santos Mayo, (301) 975-2045]

Dimensional Metrology

Postek, M.T., **Non-Destructive Submicron Dimensional Metrology Using the Scanning Electron Microscope**, Review of Progress in NDE, Vol. 6B, D.O. Thompson and D.E. Chimenti, eds. (Plenum Publishing Corporation, 1987), pp. 1327-1338.

The increasing evolution of microelectronics into the submicron region necessitates non-destructive examination of these structures both for linewidth measurement and defect inspection by systems other than the optical microscope. The scanning electron microscope operated in the low beam-voltage mode has been recently employed in this work due to its potentially high spatial resolution and depth of field. This paper discusses realistic applications of the scanning electron microscope to non-destructive microelectronics inspection and metrology in light of the pres-

Dimensional Metrology (cont'd.)

ent instrument specifications and capabilities and relates them to the processing controls required for submicron metrology.
[Contact: Michael T. Postek, (301) 975-2299]

Postek, M.T., and Joy, D.C., **Submicrometer Microelectronics Dimensional Metrology: Scanning Electron Microscopy**, NBS Journal of Research, Vol. 92, No. 3, pp. 205-228 (May-June 1987).

The increasing integration of microelectronics into the submicron region for VHSIC and VLSI applications necessitates the examination of these structures both for linewidth measurement and defect inspection by systems other than the optical microscope. The low beam-voltage scanning electron microscope has been recently employed in this work due to its potentially high spatial resolution and large depth of field. This paper discusses applications of the scanning electron microscope to microelectronics inspection and metrology in light of the present instrument specifications and capabilities, and relates them to the processing controls required for submicron processing.
[Contact: Michael T. Postek, (301) 975-2299]

Integrated Circuit Test Structures

Linholm, L.W., Radack, D.J., Reeve, C.P., Cresswell, M.W., Lowry, L.R., and Pessall, N., **Test Structures and Expert Systems for Process Control**, Proceedings of SEMICON/West '87, San Mateo, California, May 19-21, 1987, pp. 54-64.

This paper describes the test structures, test results, data analysis algorithms, and a developmental expert system which can be used as a means of improving selected aspects of process control. A prototype expert system has been developed to allow rapid evaluation of selected portions of a 1-μm fabrication process. Test results from custom designed test chips containing a variety of structures comprise the input to the expert system. The output is an English-language process diagnosis. Examples of a diagnosis provided by the expert system for selected portions of a VLSI process are presented.
[Contact: Loren W. Linholm, (301) 975-2052]

Schafft, H.A., **STATUS: Interlaboratory Electromigration Experiment**, Proceedings of the 1985 Wafer Reliability Assessment Workshop, Lake Tahoe, California, October 21-23, 1985, O.D. Trapp, ed., pp. 213-216 (1986).

An update is presented of an interlaboratory electromigration experiment now underway. The purpose of the experiment is to assess the reproducibility of electromigration characterizations and to develop guidelines for the design of test structures, for methods to measure t_{50}, and for reporting characterization results. Fourteen laboratories, including two universities, are participating in the experiment.
[Contact: Harry A. Schafft, (301) 975-2234]

Power Devices

Blackburn, D.L., **Turn-Off Failure of Power MOSFET's**, IEEE Transactions on Power Electronics, Vol. PE-2, No. 2, pp. 136-142 (April 1987). [Identical paper appeared in PESC '85, Proceedings of the Power Electronics Specialists Conference, Toulouse, France, June 24-28, 1985, pp. 429-435.]

Experimental results of the failure of power MOSFET's during inductive turn-off are discussed. The electrical characteristics of these devices during failure are shown to be identical to those of a bipolar transistor undergoing second breakdown. Other comparisons of the power MOSFET failure and bipolar second breakdown are made. A nondestructive measurement system is used

Power Devices (cont'd.)

that allows repeated measurements of the failure characteristics as a function of various parameters to be made on a single device. It is shown that commercially available power MOSFETs do not fail as a result of dV/dt currents. Drain voltage slew rates up to 22 V/ns were studied. Other measurements show that the drain voltage at which failure occurs increases with temperature, the critical current above which failure occurs decreases with temperature, and the magnitude of the load inductance has no effect on the failure. The results of this study are consistent with the theory that activation of the parasitic bipolar transistor initiates the power MOSFET failure during turn-off.
[Contact: David L. Blackburn, (301) 975-2053]

Insulators and Interfaces

Carver, G.P., Novotny, D.B., Hershey, R., and Luther, J.E., **Double-Level Metallization: Annual Report for October 1, 1985 to September 30, 1986**, NBSIR 87-3579 (June 1987).

An outline for a double-level metal process for the fabrication of circuits having a minimum linewidth of 3 μm is described. The process is designed to be implemented in the Microelectronics Processing Facility at Fort Meade, Maryland, where single-level metallization circuits are already in production. A summary is included of the related research performed in the Semiconductor Processing Research Laboratory at the National Bureau of Standards.
[Contact: Gary P. Carver, (301) 975-2091]

Chandler-Horowitz, D., and Candela, G.A., **Ellipsometric Instrumentation for Optical Metrology in Thin Films**, Proceedings of SEMICON/West '87, San Mateo, California, May 19-21, 1987, pp. 126-132.

Nondestructive optical characterization of thin-film structures on substrates by ellipsometry is a precise measurement technique which may lead to accurate metrology. In order to study problems important to semiconductor technology, we have built a spectroscopic, multi-angle of incidence, rotating-analyzer ellipsometer. The primary metrological requirement for accuracy is to obtain the uncertainties in the instrumental data for a particular sample surface. These data are the ellipsometric values for Δ, ψ, the angle of incidence ϕ, and the wavelength λ. Then a mathematical analysis involving surface modeling is performed to find both the best values of the film parameters and their uncertainties. In practice there are conditions which can optimize both the uncertainties in Δ and ψ, and the resulting uncertainties in the film parameters. Both the angles of incidence and of the polarizer can be adjusted for optimum accuracy in determining the values for Δ and ψ when the instrument is used in the rotating-analyzer mode. The ability of this instrument with its increased accuracy can lead to a better understanding of complex multilayered samples, such as proposed semiconductor device starting materials, e.g., SIMOX.
[Contact: Deane Chandler-Horowitz, (301) 975-2084]

Mountain, D.J., Galloway, K.F., and Russell, T.J., **The Effect of Post-Oxidation Anneal on the Electrical Characteristics of Thin Oxides**, Journal of the Electrochemical Society, Vol. 134, No. 3, pp. 747-479 (March 1987).

In this study, the effects of pre- and post-oxidation treatments on thin (~20-nm) gate oxide properties have been evaluated. Pre-oxidation cleans and post-oxidation anneal (POA) times and ambients were compared. Flatband voltage, oxide field breakdown, and average density of interface trap measurements were used to evaluate the different sequences. The data indicate that an optimum oxidation sequence for thin gate oxides can be designed. A

Insulators and Interfaces (cont'd.)

sacrificial oxidation cleaning procedure and a long (120-min) POA in nitrogen gave the oxide with the best electrical characteristics.
[Contact: Thomas J. Russell, (301) 975-2073]

FAST SIGNAL ACQUISITION, PROCESSING, AND TRANSMISSION

Waveform Metrology

Sorrells, J.R., **A Survey of Electronic Measurement Needs Below 10 MHz**, NBSIR 87-3549 (June 1987).

The results of a survey to assess the electronic measurement needs from dc to 10 MHz are presented. The questionnaire used in the survey covered three broad areas of measurement need: 1) basic electrical quantities and related precision instruments, 2) automatic test equipment and other complex measurement systems, and 3) conducted electromagnetic interference. The data provided by 527 respondents are summarized, and the results of various analyses are described. Several conclusions, suggested by the analyses, are also discussed.
[Contact: Barry A. Bell, (301) 975-2402]

Souders, T.M., Schoenwetter, H.K., and Hetrick, P.S., **Characterization of a Sampling Voltage Tracker for Measuring Fast, Repetitive Signals**, Proceedings of the IEEE Instrumentation and Measurement Technology Conference, IMTC/87, Boston, Massachusetts, April 27-29, 1987, pp. 240-243.

An equivalent time-sampling and digitizing system is described, together with test methods for characterizing its dynamic performance. Time-base errors, linearity errors, step-response parameters, and frequency response are considered, and typical measurement results are included. The system is capable of state-of-the-art measurements at rf frequencies.
[Contact: T. Michael Souders, (301) 975-2406]

Stenbakken, G.N., **Characterizing Square and Triangular Waveforms**, Proceedings of the IEEE Instrumentation and Measurement Technology Conference, IMTC/87, Boston, Massachusetts, April 27-29, 1987, pp. 9-11.

A method has been developed for determining the parameters and errors of square and triangular waveforms relative to idealized waveforms, even when the waveforms to be characterized are highly distorted. The method is based on measurements obtained by sampling the waveform. Then, an idealized waveform is fitted to the sampled data using a least-squared-error algorithm. The errors in the waveform are defined as the deviations between the data samples and the ideal waveform. Also, the parameters of the measured waveform are defined as the corresponding parameters of the fitted ideal waveform.
[Contact: Gerard N. Stenbakken, (301) 975-2440]

Stenbakken, G.N., Laug, O.B., Kibalo, T.H., Bell, B.A., and Perrey, A.G., NBS Wideband Sampling Wattmeter, NBS Technical Note 1221 (May 1987).

The design and operation of a wideband sampling wattmeter capable of measuring distorted power signals with fundamental frequencies from 1 Hz to 10 kHz and harmonics up to 100 kHz is described. The microcomputer-controlled wattmeter uses asynchronous sampling of the voltage and current signals. The errors associated with this type of operation are described, as are various methods of correcting some of these errors. A hardware multiplier-accumulator allows a large number of power signal samples to be integrated for each measurement. Sampling rates are variable up to a maximum of 300 kHz. A direct-memory-access unit is used to capture 4096 samples of both the voltage and current signals. These data are used to calcu-

Waveform Metrology (cont'd.)

late the average and rms values of these signals.

A special feature of the sampling wattmeter is the use of programmable time delay circuits to compensate for differential time delays between the two input channels. Performance tests of the wattmeter show that it has a measurement uncertainty of less than ±0.1 percent of full-scale amplitude over the above-described frequency range.

This technical note gives schematic diagrams of the circuits used in this wattmeter and describes their operation. The software is also described, and flow charts and selected program listings are provided for the programs written in PASCAL. The results of calibration of the instrument over the past year are also presented.
[Contact: Gerald N. Stenbakken, (301) 975-2440]

Turgel, R.S., and Vecchia, D.F., **Precision Calibration of Phase Meters**, Proceedings of the IEEE Instrumentation and Measurement Technology Conference, IMTC/87, Boston, Massachusetts, April 27-29, 1987, pp. 135-137.

A procedure and statistical analysis for the calibration of precision phase meters has been developed. The method can be applied equally to the calibration of any instrument that has a nominally linear response characteristic. Using statistical tests, the method checks whether the calibration data fit a linear model and then determines the linear equation from which the corrected calibration values are computed. Because random fluctuations tend to mask the limiting mean of the instrument response, the corrections are based on the values computed from the calibration curve, rather than on the actual calibration data.

To obtain the data, test points are chosen to cover the range to be calibrated, and several sets of calibration readings are taken by comparing the instrument under test to a standard. The replication of the data at the selected test points serves to characterize the repeatability and to decide whether the linear model is appropriate. If the assumption of a linear model is correct, the data are fitted to a straight line (calibration curve), and statistical tests are used to determine if the slope and intercept of the calibration curve are significantly different from their ideal values.

As a next step, the error limits of the readings from the instrument under test are computed for three conditions: no corrections applied, only a constant correction applied, and the full calibration curve used for the corrections. The three error limits are then compared to the instrument specifications to determine which type of calibration correction, if any, is needed.
[Contact: Raymond S. Turgel, (301) 975-2420]

Cryoelectronic Metrology

Cirillo, M., and Lloyd, F.L., **Phase Lock of a Long Josephson Junction to an External Microwave Source**, Journal of Applied Physics, Vol. 61, No. 7, pp. 2581-2585 (April 1987).

A long Josephson junction dc biased on a zero-field singularity and emitting radiation at microwave frequencies is irradiated with external microwave power. This power can be supplied either by a room-temperature oscillator or by another long junction. We find that the oscillations of the junction can lock coherently to the external signal for frequency intervals ranging from 500 kHz to 50 MHz. The dependence of the width of these intervals of coherence on the external microwave power is measured for the case in which the power is generated by a room-temperature oscillator.
[Contact: Frances L. Lloyd, (303) 497-3254 or 3988]

Cryoelectronic Metrology (cont'd.)

Crete, D.G., McGrath, W.R., Richards, P.L., and Lloyd, F.L., **Performance of Arrays of SIS Junctions in Heterodyne Mixers**, IEEE Transactions on Microwave Theory and Techniques, Vol. MTT-35, No. 4, pp. 435-440 (April 1987).

We have made a systematic experimental study of the performance of millimeter-wave quasiparticle heterodyne mixers which use arrays of superconductor-insulator-superconductor (SIS) tunnel junctions. Sets of arrays with N = 1, 5, 10, 25, and 50 junctions in series were fabricated by photolithography. All of the arrays in a given set were made on a single wafer so that their response time parameters $\omega_S R_N C$ were the same (ω_S = signal frequency; R_N = junction normal-state resistance; C = junction capacitance). Junction areas were scaled so that the total impedance was the same for each array in a set. Sets of arrays from four wafers with values of $\omega_S R_N C$ ranging from 2.6 to 13 were evaluated in mixers at 33 and 36 GHz. These measurements showed that the signal power required to saturate the mixers varies as N^2, and the conversion efficiency is nearly independent of N for all values of $\omega_S R_N C$. The mixer noise temperature is independent of N for large values of $\omega_S R_N C$. Therefore, the dynamic range of an SIS quasiparticle mixer can increase in proportion to N^2. For small values of $\omega_S R_N C$, however, the mixer noise increases systematically with N. This correlation suggests that the junction capacitance affects the coupling between junctions that can contribute to the noise.
[Contact: Frances L. Lloyd, (303) 497-3254]

McDonald, D.G., **Novel Superconducting Thermometer for Bolometric Applications**, Applied Physics Letters, Vol. 50, No. 12, pp. 775-777 (March 23, 1987).

The temperature dependence of the magnetic penetration depth in a superconductor is proposed as a basis for a sensitive thermometer. This depth is monitored through the inductance of a microstrip transmission line, which is incorporated into an impedance measuring bridge. The bridge is envisioned as an integrated circuit with all critical components at low temperature. It is estimated that the contribution to the noise equivalent power by the sum of the Josephson noise and the preamplifier noise can be reduced to about 7×10^{-20} watt per root hertz, which is approximately four orders of magnitude below currently realized values. Performance of this device as a bolometer is limited by noise from the thermal conductance of the bolometer mount with the present state of the art.
[Contact: Donald G. McDonald, (303) 497-5113]

Raisanen, A.V., Crete, D.G., Richards, P.L., and Lloyd, F.L., **Low Noise SIS Mixer with Gain for 80-115 GHz**, Proceedings of the ESA Workshop on a Space-Borne Sub-Millimetre Astronomy Mission, Segovia, Spain, June 4-7, 1986, pp. 255-258 (European Space Agency, Paris, France, 1986). [See also a more extensive paper by the same authors published in the International Journal of Infrared and Millimeter Waves, Vol. 7, No. 12, pp. 1835-1852 (1986).]

Several superconductor-insulator-superconductor (SIS) quasiparticle mixers have been designed and tested for the frequency range from 80 to 115 GHz. The sliding backshort is the only adjustable radiofrequency (RF) tuning element. The RF-filter reactance is used as a fixed RF-matching element. A mixer which uses a single 2×2 μm^2 Pb-alloy junction in a 1/4-height waveguide mount has a coupled conversion gain of G_M(double sideband [DSB]) = 2.6 ± 0.5 dB with an associated noise temperature of T_M(DSB) = 16.4 ± 1.8 K at the best DSB operation point. The receiver noise temperature T_R(DSB) is 27.5 ± 0.8 K. This mixer provides a single-sideband

Cryoelectronic Metrology (cont'd.)

(SSB) receiver noise temperature below 50 K over the frequency range from 91 to 96 GHz, the minimum being $T_R(SSB) = 44 \pm 4$ K.
[Contact: Frances L. Lloyd, (303) 497-3254 or -3988]

Raisanen, A.V., Crete, D.G., Richards, P.L., and Lloyd, F.L., **Wide-Band Low Noise MM-Wave SIS Mixers With a Single Tuning Element**, International Journal of Infrared and Millimeter Waves, Vol. 7, No. 12, pp. 1835-1852 (1986).

Several superconductor-insulator-superconductor (SIS) quasi-particle mixers have been designed and tested for the frequency range from 80 to 115 GHz. The sliding backshort is the only adjustable radiofrequency (RF) tuning element. The RF filter reactance is used as a fixed RF matching element. A mixer which uses a single 2×2 μm^2 Pb-alloy junction in a quarter-height waveguide mount has a coupled conversion gain of G_M(double sideband [DSB]) $= 2.6 \pm 0.5$ dB with an associated noise temperature of $T_M(DSB) = 16.4 \pm 1.8$ K at the best DSB operation point. The receiver noise temperature $T_R(DSB)$ is 27.5 ± 0.8 K for the mixer test apparatus. This mixer provides a single-sideband (SSB) receiver noise temperature below 50 K over the frequency range from 91 to 96 GHz, the minimum being $T_R(SSB) = 44 \pm 4$ K. Another mixer with an array of five 5×5 μm^2 junctions in series in a full-height-waveguide mount has much lower noise temperature $T_M(DSB) = 6.6 \pm 1.6$ K, but less gain $G_M(DSB) = -5.1 \pm 0.5$ dB.
[Contact: Frances L. Lloyd, (303) 497-3254 or -3988]

Antenna Metrology

FitzGerrell, R.G., **Standard Linear Antennas, 30 MHz to 1000 MHz**, Proceedings of the Fifth International Conference on Electromagnetic Compatibility, University of York, England, September 29-October 2, 1986 (Sponsored by the Institution of Electronic & Radio Engineers, London, England), pp. 147-153.

Simple linear antennas are described that are designed to operate in the 30-MHz to 1000-MHz frequency range. Commercial coaxial hybrid junctions are used as balanced-to-unbalanced transmission line transformers (baluns) for the dipole antennas. The monopoles are fed unbalanced against a large ground screen. Calculated site attenuation (insertion loss) between pairs of these antennas over an assumed perfectly conducting plane ground is compared to insertion loss data measured using the 30 m by 60 m NBS ground screen. It is assumed that one-half of the mean value of the difference between the calculated and measured insertion loss data, expressed in decibels, is a good estimate of individual antenna performance. For the antennas described here, this measure of performance is typically ≤ 0.05 dB and on the outside, ≤ 0.42 dB.
[Contact: Richard G. FitzGerrell, (303) 497-3737]

Muth, L.A., **Displacement Errors in Antenna Near-Field Measurements and Their Effect on the Far Field**, NBS Technical Note 1306 (October 1986) [also accepted for publication in IEEE Transactions on Antennas and Propagation].

The effects of probe-displacement errors in the near-field measurement procedure on the far-field spectrum are studied. Expressions are derived for the displacement error functions that maximize the fractional error in the spectrum both for the on-axis and off-axis directions. Planar x-y and z-displacement errors are studied first, and the results generalized to position errors in cylindrical and spherical scanning. Near-field models are used to obtain order-of-magnitude estimates for the fractional error as a function of relevant scale lengths of the near field, defined as the lengths over which significant variations occur.

Antenna Metrology (cont'd.)

[Contact: Lorant A. Muth, (303) 497-3603]

Laser Metrology

Bennett, H.E., Guenther, A.H., Milam, D., and Newnam, B.E., **Laser Induced Damage in Optical Materials: 1984,** NBS Special Publication 727 (October 1986).

The Sixteenth Annual Symposium on Optical Materials for High Power Lasers (Boulder Damage Symposium) was held at the National Bureau of Standards in Boulder, Colorado, October 15-17, 1984. The Symposium was held under the auspices of ASTM Committee F-1, Subcommittee on Laser Standards, with the joint sponsorship of NBS, the Defense Advanced Research Projects Agency, the Department of Energy, the Office of Naval Research, and the Air Force Office of Scientific Research. Approximately 200 scientists attended the Symposium, including representatives of the United Kingdom, France, West Germany, and the Netherlands. The Symposium was divided into sessions concerning Materials and Measurements, Mirrors and Surfaces, Thin Films, and Fundamental Mechanisms. As in previous years, the emphasis of the papers presented at the Symposium was directed toward new frontiers and new developments. Particular emphasis was given to materials for high power apparatus. The wavelength range of prime interest was from 10.6 μm to the uv region. Highlights included surface characterization, thin-film-substrate boundaries, and advances in fundamental laser-matter threshold interactions and damage mechanisms. Harold E. Bennett of the Naval Weapons Center, Arthur H. Guenther of the Air Force Weapons Laboratory, David Milam of the Lawrence Livermore National Laboratory, and Brian E. Newnam of the Los Alamos National Laboratory were co-chairmen of the Symposium. The Seventeenth Annual Symposium was scheduled for October 28-30, 1985 at the National Bureau of Standards, Boulder.
[Contact: Aaron A. Sanders, (303) 497-5341]

Microwave and Millimeter-Wave Metrology

Adair, R., Reeve, G., and Gatterer, L.E., **The Expanding Need for Microwave and Millimeter Wave Calibration Services,** National Conference of Standards Laboratories Newsletter, Vol. 27, No. 1, pp. 21-31 (January 1987).

Several technology surveys concerning microwave- and millimeter-wave measurement needs and capabilities have recently been conducted by the National Bureau of Standards Boulder Laboratories, and other organizations. The results of some of these studies which covered the frequency range from 1 GHz to above 200 GHz are summarized. Current microwave- and millimeter-wave standards and calibration capabilities at the National Bureau of Standards are reviewed and compared with national needs. The lack of national standards in certain frequency bands may lead to problems with the specification, acceptance testing, calibration, and critical use of some components and systems. Plans to fulfill unmet needs in the frequency range are also presented.
[Contact: Gerome R. Reeve, (303) 497-3557]

Daywitt, W.C., **A Simple Technique for Determining Joint Losses on a Coaxial Line from Swept-Frequency Reflectometer Data,** CPEM 86 Digest, 1986 Conference on Precision Electromagnetic Measurements, R.F. Dziuba, Editor, National Bureau of Standards, Gaithersburg, Maryland, June 23-27, 1986, p. 40.

A need to separate connector loss from swept-frequency automatic network analyzer measurements to check an attenuation calculation for a low-loss, coaxial line has led to a simple graphical technique for determining the connector loss. It is also possible to determine joint losses around center conductor

Microwave & Millimeter-Wave (cont'd.)

bead supports on the line itself. Preliminary results indicate that losses in the milli-decibel range can be determined to a precision of a few tenths of a milli-decibel or better, even though the data are obscured by considerable connector loss and calibration error. Results were checked by independent measurements and show excellent agreement.
[Contact: William C. Daywitt, (303) 497-3720]

Engen, G.F., **In Search of a More Realistic Accuracy Statement for Microwave Metrology**, 27th ARFTG (Automatic RF Techniques Group) Conference Digest, Baltimore, Maryland, June 5-6, 1986, pp. 181-183 (August 1986).

The concept of "measurement accuracy" is fundamental to all of metrology. Given two different techniques for measuring the same parameter, an evaluation of their respective accuracies typically plays a major role in an assessment of their relative merit.

Historically, the accuracy achieved by the microwave metrologist has been limited by detector performance, hardware imperfections, and connector problems. Today, the effect of hardware imperfections has been largely eliminated by more complete modeling. Moreover, the performance of the detection systems has been improved to the point where in many cases the non-ideal connector behavior is the major error source. Although important refinements in the connectors have also been realized, it is quite possible that these have not kept pace with the other developments.

In any case, it is useful to pose the following question: Assume a measurement system which, apart from being fitted with connectors typical of those in general use, is otherwise perfect. How much measurement accuracy can one realistically claim for it?

[Contact: William E. Little, (303) 497-5479]

McDonald, D.G., **Novel Superconducting Thermometer for Bolometric Applications**, Applied Physics Letters, Vol. 50, No. 12, pp. 775-777 (March 23, 1987).

The temperature dependence of the magnetic penetration depth in a superconductor is proposed as a basis for a sensitive thermometer. This depth is monitored through the inductance of a microstrip transmission line, which is incorporated into an impedance measuring bridge. The bridge is envisioned as an integrated circuit with all critical components at low temperature. It is estimated that the contribution to the noise equivalent power by the sum of the Josephson noise and the preamplifier noise can be reduced to about 7×10^{-20} watt per root hertz, which is approximately four orders of magnitude below currently realized values. Performance of this device as a bolometer is limited by noise from the thermal conductance of the bolometer mount with the present state of the art.
[Contact: Donald G. McDonald, (303) 497-5113]

Optical Fiber Metrology

Day, G. W., **Compact Fiber Sensors for the Measurement of Low Level Electric Currents**, Proceedings of the 4th International Conference on Optical Fiber Sensors, Tokyo, Japan, October 7-9, 1986, pp. 81-84.

Recent progress in the development of fiber current sensors includes the fabrication of low-loss, low-birefringence, 3-cm diameter coils by annealing, and the demonstration of a noise equivalent current of 180 microamperes per root Hertz.
[Contact: Gordon W. Day, (303) 497-5204]

Engelsrath, A., Danielson, B.L., and Franzen, D.L., **Attenuation Measure-**

Optical Fiber Metrology (cont'd.)

ments on Deformed Optical Fibers, NBSIR 86-3052 (July 1986).

Attenuation measurements were made on several different optical fibers subjected to bending, tension, twisting, and overlapping. The measurements were performed with an optical time-domain reflectometer which gives a partial separation between the various contributions to the measured deformation loss. The graded- and step-index multimode fibers had a variety of different dimensions and coatings. The results of bending attenuation are compared with models and other reported experimental loss data. Based on the results of the present experiments, an empirical model has been derived which permits a prediction of the smallest bend radius consistent with a given allowed attenuation.
[Contact: Bruce L. Danielson, (303) 497-5620]

Franzen, D.L., **Standard Measurement Procedures for Characterizing Single-Mode Fiber,** Conference Digest, Test & Measurement World Expo, San Jose, California, April 8-10, 1986, pp. 70-77 (October 1986).

Parameters used to describe single-mode fiber include attenuation, cut-off wavelength, mode-field diameter, and dispersion. Some measurement results depend on test-fiber condition and testing methods.
[Contact: Douglas L. Franzen, (303) 497-3346 or -5342]

Gallawa, R.L., and Li, X., **Calibration of Optical Fiber Power Meters: The Effect of Connectors,** Applied Optics, Vol. 26, No. 7, pp. 1170-1174 (April 1987).

This paper addresses the question of accurate measurement of optical power at the wavelengths and power levels of interest to the telecommunications community. In particular, we examine the calibration of power meters that are destined for use in a field environment. Connectors and adapters are shown to skew the measurements, leading to errors attributable to reflections from the connector or to angular dependence of detector response. Calibration data are taken using two popular connector types: a biconic and an SMA type. The data are sufficient to illustrate the problem but definitive conclusions cannot be drawn regarding variability of performance with connector or connector type, because of the limited data.
[Contact: Robert L. Gallawa, (303) 497-3761]

Maisonneuve, J., and Gallawa, R.L., **The Use of Power Transfer Matrices in Predicting System Loss: Theory and Experiment,** Fiber and Integrated Optics, Vol. 6, No. 1, pp. 11-26 (1985).

The phase space diagram for parabolic and step-index fibers leads to a graphic representation of the bound, leaky, and refracted rays of ray theory. This concept is used to predict the attenuation of typical components of local area networks. The technique uses power transfer matrices to track the evolution of power distribution in ray packets. In particular, we predict and then measure the power transfer of two ray packets for a step-index fiber. The comparison is encouraging.
[Contact: Robert L. Gallawa, (303) 497-3761]

Electro-Optic Metrology

Day, G.W., Hale, P.D., Deeter, M., Milner, T.E., Conrad, D., and Etzel, S.M., **Limits to the Precision of Electro-Optic and Magneto-Optic Sensors,** NBS Technical Note 1307 (March 1987). [Original title: High-Precision Electro-Optic and Magneto-Optic Sensors for Power System Applications: Technical Feasibility].

The principles of electro-optic and magneto-optic sensors suitable for use in power system applications are

Electro-Optic Metrology (cont'd.)

reviewed with particular attention to the properties of materials and components that limit the precision of such sensors. Section topics include precision and accuracy in electro-optic and magneto-optic sensors; electro-optic and magneto-optic sensor configurations suitable for current and voltage measurements; critical evaluation of electro-optic sensor technology; critical evaluation of magneto-optic sensor technology; and suggested approaches to the development of high-precision optical current and voltage sensors. Data on a number of materials are collected and presented. For high-precision electro-optic sensors, it is recommended that crystals of the polar class having point symmetry $\bar{4}3$ m be used. For high-precision magneto-optic sensors, a lead glass with a low stress-optic coefficient is recommended. Choices for other components are also suggested. For both types of sensors, a precision of roughly ±1% over a 100°C temperature range should be attainable. To achieve a precision better than that, it will be necessary to use temperature compensation techniques, several of which are proposed and discussed.
[Contact: Gordon W. Day, (303) 497-5204]

Franzen, D.L., Yamabayashi, Y., and Kanada, T., **Optical Sampling with Gain-Switched, Pulse-Compressed Distributed-Feedback Laser Diodes**, Electronics Letters, Vol. 23, No. 6, pp. 289-290 (March 1987).

Chirped pulses from gain-switched, distributed feedback laser diodes at a wavelength of 1.3 μm are compressed to 8.7 ps full width at half maximum by the linear dispersion properties of single-mode fiber. These pulses are used to optically sample fast waveforms from other 1.3-μm laser diodes. The high time resolution sampling system uses a fibre coupler to combine beams; this eliminates critical alignment and results in a practical design.
[Contact: Douglas L. Franzen, (303) 497-3346 or -5342]

Young, M., and Weppner, M., **Hybrid Computer-Optical Processing With Inexpensive Liquid Crystal Television**, Proceedings of the 1986 International Optical Computing Conference, Jerusalem, Israel, July 6-11, 1986, pp. 146-153 [SPIE - The International Society for Optical Engineering, P.O. Box 20, Bellingham, WA 98227].

We describe a computer-optical processing system that uses an inexpensive liquid crystal television monitor and a selective holographic filter for coherent pattern recognition. Specifically, we use a digital computer to generate an edge-enhanced image of an object, expose a Fourier transform hologram of this image, and use the hologram as a sort of matched filter for recognizing the original object in real time.
[Contact: Matt Young, (303) 497-3223 or -5342]

Complex Testing

Leedy, T.F., **A View of Metrology Support for ATE Systems**, The Reflector, Vol. 35, No. 9, p. 20 (May 1, 1987).

Several approaches are used to assure that automatic test equipment (ATE) performs properly. The traditional approach is the calibration and adjustment of critical instruments contained in the automatic test system by a calibration laboratory where the performance of the instrumentation is evaluated and any necessary adjustments are made. However, the normal operating environment experienced by the equipment in the ATE system may be quite different than that encountered in the calibration laboratory where such effects as elevated temperature and the presence of high-frequency interfering signals (possibly produced by other instrumentation and computers in the ATE system) may degrade the performance of precision

Complex Testing (cont'd.)

measurement equipment. Thus, the user of an ATE system, which has had instruments removed and calibrated in a laboratory, may have greater confidence in the equipment performance than is warranted.

Another calibration approach employed with ATE systems is the use of various types of built-in test or self-testing schemes. If properly implemented, such schemes may be valuable towards assuring that measurements made by an ATE system are consistent. However, such techniques alone cannot perform a calibration function to determine the difference between values of physical quantities, such as voltage and frequency, measured by the ATE system and those measured quantities that have traceability to national standards. For successful calibration of a test system, a combination of traditional laboratory calibration techniques and built-in test techniques is usually desirable.
[Contact: Thomas F. Leedy, (301) 975-2410]

Other Fast Signal Topics

Sorrells, J.R., **A Survey of Electronic Measurement Needs Below 10 MHz**, NBSIR 87-3549 (June 1987).

The results of a survey to assess the electronic measurement needs from dc to 10 MHz are presented. The questionnaire used in the survey covered three broad areas of measurement need: 1) basic electrical quantities and related precision instruments, 2) automatic test equipment and other complex measurement systems, and 3) conducted electromagnetic interference. The data provided by 527 respondents are summarized, and the results of various analyses are described. Several conclusions, suggested by the analyses, are also discussed.
[Contact: Barry A. Bell, (301) 975-2402]

Weppner, M., and Young, M., **Image Processing for Optical Engineering Applications**, NBSIR 87-3065 (April 1987).

This report describes the development and testing of image processing software designed for optical engineering applications. Image processing functions in this software include two-dimensional Fourier transforms, convolution, noise reduction, multiple image resolutions, and low-level image processing functions. The software also contains image information display tools including Gaussian beam and g-profile characterization for optical fiber measurements. The necessary image file input/output routines are presented in the software and are used to read and store images in conjunction with other image processing software, digitizing cameras, and output display devices.
[Contact: Matthew Weppner, (303) 497-3223]

ELECTRICAL SYSTEMS

Power Systems Metrology

Laug, O.B., **A Precision Power Amplifier for Power/Energy Calibration Applications**, Proceedings of the IEEE Instrumentation and Measurement Technology Conference, IMTC/87, Boston, Massachusetts, April 27-29, 1987, pp. 129-134.

A precision power amplifier for use in power/energy calibration applications is described. The amplifier was primarily designed to boost the output amplitude of a dual-channel digital generator to provide the nominal 120 or 240 rms voltage component of a "phantom" calibration power source. The amplifier has a fixed gain of 40 and can provide a maximum output voltage swing of 970 V peak-to-peak or 340 V rms at 100 mA rms. The bandwidth is from dc to 150 kHz, and at 60 Hz the observed no-load, short-term amplitude and phase instabilities are ±5 ppm and ±5 microradians, respectively. The amplifier design uses high-voltage N-channel MOSFETs in the output driver

Power Systems Metrology (cont'd.)

stage together with a unique circuit topology of opto-isolators between the low-level input stage and the high-level output stage.
[Contact: Owen B. Laug, (301) 975-2412]

Misakian, M., McKnight, R.H., and Fenimore, C., **Calibration of Aspirator-Type Ion Counters and Measurement of Unipolar Charge Densities**, Journal of Applied Physics, Vol. 61, No. 4, pp. 1276-1287 (February 15, 1987). [A more extended treatment of this topic is given in NBS Technical Note 1223 (May 1986).]

The characterization of a parallel plate apparatus which can produce a unipolar charge density that is suitable for calibrating aspirator-type ion counters operating in the ground plane is described. Influences of a dc electric field, air motion, Coulomb repulsion, and diffusion on the transport of ions into the ion counter are examined to determine their effects on instrument calibration and measurements in the vicinity of high-voltage dc transmission lines. A charge density which is known with an uncertainty of less than ±9% is used to check the performance of an ion counter with and without a duct at its entrance.
[Contact: Martin Misakian, (301) 975-2426]

Van Brunt, R.J., **Common Parameterizations of Electron Transport, Collision Cross Section, and Dielectric Strength Data for Binary Gas Mixtures**, Journal of Applied Physics, Vol. 61, No. 5, pp. 1773-1787 (March 1, 1987).

Previously used parameterizations of dielectric strengths (electrical breakdown data) for gas mixtures in terms of electron collision and transport parameters are reviewed. A new method of fitting experimental data on dielectric strengths for binary electronegative gas mixtures is proposed based upon the principal assumption that the electron kinetic energy distributions in the gas are Maxwellian. The method provides physical insight into such behavior as pressure-dependent or pressure-independent synergisms, and is useful in checking the consistency between dielectric strength data and available information on electron transport and ionization, attachment, and momentum transfer collision cross sections. The method is applied here to the mixtures SF_6/N_2, $CC\ell_2F_2/N_2$, and $SF_6/CC\ell_2F_2$.
[Contact: Richard J. Van Brunt, (301) 975-2425]

Superconductors

Goodrich, L.F., Bray, S.L., Dube, W.P., Pittman, E.S., and Clark, A.F., **Development of Standards for Superconductors, Interim Report, January - December 1985**, NBSIR 87-3066 (April 1987).

A cooperative program with the Department of Energy, the National Bureau of Standards, and private industry is in progress to develop standard measurement practices for use in large-scale applications of superconductivity. The goal is the adoption of voluntary standards for the critical parameters and other characterizations of practical superconductors. Progress for the period January through December 1985 is reported. The major effort was the measurement of large conductor critical current. Other work reported here includes stability and a discussion of possible future Standard Reference Materials.
[Contact: Loren F. Goodrich, (303) 497-3143]

Magnetic Materials and Measurements

Goldfarb, R.B., and Bussey, H.E., **Method for Measuring Complex Permeability at Radio Frequencies**, Review of Scientific Instruments, Vol. 58, No. 4, pp. 624-627 (April 1987).

An established method for measuring complex rf magnetic permeability is

Magnetic Materials, etc. (cont'd.)

based on the change in inductance and resistance of a coaxial transmission line upon insertion of a sample toroid. It is not necessary to wind coils on the toroid or to correct for geometric demagnetization factors. The use of modern commercial impedance analyzers, as described in this paper, makes measurements from 1 kHz to 1 GHz particularly easy, fast, and accurate.
[Contact: Ronald B. Goldfarb, (303) 497-3650]

Moulder, J.C., and Capobianco, T.E., **Detection and Sizing of Surface Flaws With a SQUID-Based Eddy Current Probe,** Journal of Research of the National Bureau of Standards, Vol. 92, No. 1, pp. 27-33 (January-February 1987).

In a new approach to eddy current detection and sizing of surface-breaking flaws, we have coupled a conventional reflection probe to a superconducting quantum interference device (SQUID) to produce an eddy current probe with increased sensitivity and signal-to-noise ratio. The reflection probe consists of an air-core excitation coil surrounding two counterwound ferrite-core pickup coils connected in series. A room-temperature probe is inductively coupled to a SQUID, which operates in a liquid helium bath. The new probe was used to obtain flaw signals from a number of electrical-discharge machined (EDM) slots in aluminum alloy 6061. Results indicated that by scanning the probe along the length of the flaw, the length could be determined from the extent of the flaw signal. The peak amplitude of the flaw signal was found to be proportional to the cross-sectional area of the flaw. Empirical calibration curves relating these quantities were used to invert successfully the experimental data obtained for the EDM slots.
[Contact: Thomas E. Capobianco, (303) 497-3141]

ELECTROMAGNETIC INTERFERENCE

Radiated Electromagnetic Interference

Crawford, M.L., and Koepke, G.H., **Preliminary Evaluation of Reverberation Chamber Method for Pulsed RF Immunity Testing,** Proceedings of the IEEE International Symposium on Electromagnetic Compatibility, San Diego, California, September 16-18, 1986, pp. 270-278.

This paper describes the evaluation of the performance characteristics of a reverberation chamber excited by pulsed rf (1.0 μs to 10 μs, 0.001 duty cycle) in the frequency range, 0.9 GHz to 10 GHz. The purpose of this work was to investigate the potential use of a reverberation chamber for pulsed rf immunity testing of electronic equipment. Information given includes a description of the reverberation chamber evaluated, the instrumentation used for performing the measurements, and results obtained showing the pulse dispersion characteristics of the chamber.
[Contact: Myron L. Crawford, (303) 497-5497]

Hill, D.A., **An Error Bound for Near-Field Array Synthesis,** IEEE Transactions on Electromagnetic Compatibility, Vol. EMC-28, No. 4, pp. 273-276 (November 1986).

An expression for the upper bound of any component of the electric or magnetic field at any point in a region is derived in terms of a product of two surface field integrals. The result is most useful for bounding errors in near-field array synthesis, but might have other applications where upper bounds on field magnitudes are desired.
[Contact: David A. Hill, (303) 497-3472]

Hill, D.A., **Radio-Wave Propagation From a Forest to a Clearing,** Electromagnetics, No. 6, pp. 217-228 (1986).

Kirchhoff integration over a vertical aperture is used to obtain a simple expression for radio-wave propagation

Radiated EMI (cont'd.)

from a forest to a clearing. Numerical results are presented for a frequency of 10 MHz, and the classical recovery effect is observed. Numerical comparisons are made with a previous integral equation solution, and the agreement is good.
[Contact: David A. Hill, (303) 497-3472]

Hill, D.A., and Koepke, G.H., **A Near-Field Array of Yagi-Uda Antennas for Electromagnetic Susceptibility Testing**, IEEE Transactions on Electromagnetic Compatibility, Vol. EMC-28, No. 4, pp. 170-178 (November 1986) [condensed version of NBS Technical Note 1082, July 1985].

In electromagnetic-susceptibility testing of electronic equipment, the ideal incident field is a plane wave. To approximate this condition, a seven-element array of Yagi-Uda antennas has been constructed and tested at a frequency of 500 MHz. The element weightings are determined by a near-field synthesis technique, which optimizes the uniformity of the field throughout a rectangular test volume in the near field of the array. The amplitude and phase of the electric field have been measured throughout the test volume with a short-dipole probe, and the agreement with theory is excellent.
[Contact: David A. Hill, (303) 497-3472]

Kanda, M., and Driver, L., **An Isotropic Electric-Field Probe With Tapered Resistive Dipoles for Broadband Use, 100 kHz-18 GHz**, IEEE Transactions on Microwave Theory and Techniques, Vol. MTT-35, No. 2, pp. 124-130 (February 1987) [also appeared in the Proceedings of the IEEE International Symposium on Electromagnetic Compatibility, San Diego, California, September 16-18, 1986, pp. 256-261].

A new broadband electric-field probe, capable of accurately characterizing and quantifying electromagnetic (EM) fields, has been developed at the National Bureau of Standards. The probe's 8-mm resistively tapered dipole elements allow measurement of electric fields between 1 and 1600 V/m from 1 MHz to 15 GHz, with a flatness of ±2 dB. The mutually orthogonal dipole configuration provides an overall standard deviation in isotropic response, with respect to angle, that is within ±0.3 dB. Both the theoretical and developmental aspects of this prototype electric-field probe are discussed in this paper.
[Contact: Motohisa Kanda, (303) 497-5320]

Kanda, M., and Orr, R.D., **Near-Field Gain of a Horn and an Open-Ended Waveguide: Comparison Between Theory and Experiment**, Proceedings of the Fifth International Conference on Electromagnetic Compatibility, University of York, September 29-October 2, 1986 (sponsored by the Institution of Electronic and Radio Engineers, London, England), pp. 137-145.

This paper gives the theory and supporting experimental measurements for the near-field gain of a rectangular pyramidal horn and an open-ended waveguide (OEG) at 450 MHz. The empirical near-field gain for the OEG is derived from experimental results obtained by a two-antenna method at about 2 GHz. The theoretical near-field gain for the rectangular pyramidal horn is derived from Schelkunoff's formula. Two independent near-field gain measurements of these antennas are made using a three-antenna method and a transfer-standard-probe method. The discrepancy between theoretical and experimental results is typically less than ±1 dB.
[Contact: Motohisa Kanda, (303) 497-5320]

Randa, J.P., and Kanda, M., **A Lattice Approach to Complex Electromagnetic Environments**, Proceedings of the IEEE International Symposium on Electromagnetic Compatibility, San Diego, California, September 16-18, 1986, pp.

Radiated EMI (cont'd.)

329-331.

We outline an approach to the characterization of complicated electromagnetic environments based on a lattice (finite-difference) approximation to Maxwell's equations. Approximate solutions to the equations are found numerically, subject to constraints imposed by boundary conditions and by measurements of the field at some number of points. The technique is illustrated by simple two- and three-dimensional examples.
[Contact: James P. Randa, (303) 497-3150]

Reeve, G.R., **Alternate EMI Measurement Techniques for Microelectronic Circuits**, Symposium Record, EMC EXPO 86 International Conference on Electromagnetic Compatibility, Washington, D.C., June 16-19, 1986, pp. T26.1-T26.4.

The purpose of this paper, which was orginally presented as an unpublished talk at a seminar held in March 1985 at the National Bureau of Standards in Gaithersburg, Maryland, is to suggest some new possibilities in metrology for evaluating the effects of electromagnetic interference on microelectronics and integrated circuits in particular.

With increasingly complex integrated circuits being designed for the Very-Large-Scale Integrated Circuit (VLSI) programs, and the Very High Speed Integrated Circuit (VHSIC) programs, utilizing larger chip areas and smaller device geometries, there is some concern that these units, either by themselves or in application circuits will prove more susceptible to the effects of electromagnetic interference (EMI). Existing techniques using pin voltage upset measurements may not be sufficient to properly characterize the behavior of these integrated circuits in the presence of EMI. Some possible adaptations of EMI measurement techniques presently in use or being developed at the National Bureau of Standards and other laboratories are presented for consideration.
[Contact: George R. Reeve, (303) 497-3557]

Wilson, P.F., and Ma, M.T., **Shielding Effectiveness Measurements Using an Apertured TEM Cell in a Reverberation Chamber**, Proceedings of the IEEE International Symposium on Electromagnetic Compatibility, San Diego, California, September 16-18, 1986, pp. 265-269.

Measurements of near-field shielding effectiveness are performed in a reverberation chamber using an apertured transverse electromagnetic cell as the receiver. This configuration allows one to investigate the electric- and magnetic-field shielding properties of a material simultaneously. Coupling to the cell is modeled using small-aperture theory, and predicted results agree well with measured data.
[Contact: Perry F. Wilson, (303) 497-3842]

Conducted Electromagnetic Interference

Martzloff, F.D., and Gruzs, T.M., **Power Quality Site Survey: Fact, Fiction and Fallacies**, Conference Record, Industrial & Commercial Power Systems Technical Conference, Nashville, Tennessee, May 4-7, 1987, pp. 21-33 [also to appear in IEEE Transactions on Industry Applications].

The quality of the power supplied to sensitive electronic equipment is an important issue. Monitoring disturbances of the power supply has been the objective of various site surveys, but results often appear to be instrument- or site-dependent, making comparisons difficult. After a review of the origins and types of disturbances, the types of monitoring instruments are described; a summary of nine published surveys reported in the last 20 years is presented. A close examination of underlying assumptions allows meaningful comparisons which can reconcile some of the differences. Finally, the paper

Conducted EMI (cont'd.)

makes an appeal for improved definitions and applications in the use of monitoring instruments.
[Contact: Francois D. Martzloff, (301) 975-2409]

Reeve, G.R., **Alternate EMI Measurement Techniques for Microelectronic Circuits**, Symposium Record, EMC EXPO 86 International Conference on Electromagnetic Compatibility, Washington, D.C., June 16-19, 1986, pp. T26.1-T26.4.

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[Contact: George R. Reeve, (303) 497-3557]

ADDITIONAL INFORMATION

Lists of Publications

Gibson, K.A., Page, J.M., and Miller, C.K.S., **A Bibliography of the NBS Electromagnetic Fields Division Publications, NBSIR 85-3040** (February 1986).

This bibliography lists publications of the National Bureau of Standards' Electromagnetic Fields Division for the period from January 1984 through September 1985, with selected earlier publications from the Division's predecessor organizations.
[Contact: Kathryn A. Gibson, (303) 497-3132]

Kline, K.E., and DeWeese, M.E., **Metrology for Electromagnetic Technology: A Bibliography of NBS Publications**, NBSIR 86-3048 (June 1986).

This bibliography lists the publications of the personnel of the Electromagnetic Technology Division of NBS in the period from January 1970 through December 1985. A few earlier references that are directly related to the present work of the Division are included.
[Contact: Kathryn E. Kline, (303) 497-3678]

Palla, J.C., and Meiselman, B., **Electrical and Electronic Metrology: A Bibliography of NBS Electrosystems Division Publications, NBS List of Publications 94** (January 1987).

This bibliography covers publications of the Electrosystems Division, Center for Electronics and Electrical Engineering, NBS, and of its predecessor sections for the period January 1963 to January 1987. A brief description of the Division's technical program is given in the introduction.
[Contact: Jenny C. Palla, (301) 975-2220]

Walters, E.J., **Semiconductor Measurement Technology: A Bibliography of NBS Publications for the Years 1962-1986**, NBSIR 87-3522 (February 1987).

This bibliography contains reports of work performed at the National Bureau of Standards in the field of Semiconductor

Lists of Publications (cont'd.)

Measurement Technology in the period from 1962 through December 1986. An index by topic area and a list of authors are provided. [Contact: E. Jane Walters, (301) 975-2050]

1988 CEEE CALENDAR

February 10-12 (San Diego, CA)

IEEE Semiconductor Thermal and Temperature Measurement Symposium. This fourth annual **SEMI-THERM** symposium is sponsored by the Components, Hybrids, and Manufacturing Technology Society of IEEE in cooperation with NBS and constitutes an international forum for the presentation of new developments in, and applications relating to, generation and removal of heat within semiconductor devices and measurement of junction temperatures experienced in various applications and environments. Major SEMI-THERM topic areas include thermal measurements, thermal characterization, applications, and computation and software.

The program includes keynote speakers, technical presentations, tutorial sessions, workshops, and an exhibit. In addition, the Semiconductor Equipment and Materials Institute has scheduled in conjunction with SEMI-THERM a meeting of its Thermal Measurements Task Force, to which attendees are invited. [Contact: Frank F. Oettinger, (301) 975-2054]

May 11-13 (Los Angeles, CA)

Intersociety Conference on Thermal Phenomena in Fabrication and Operation of Electronic Components. This Conference is sponsored by the Components, Hybrids, and Manufacturing Technology Society of the IEEE, in cooperation with ASME Committee K-16 on Heat Transfer and NBS. It is intended to provide an interdisciplinary forum for exploring the progress made in understanding, analyzing, and modeling thermal transport processes and thermally induced failures in the fabrication, assembly, and use of logic, memory, and data-storage systems. Major topic areas covered are 1) processing and fabrication, including state-of-the-art semiconductor crystal growing techniques; thermal stress in wafers, chips, substrates, PC boards, and joints; and encapsulant behavior with respect to solidification, outgassing, mechanical properties, and water vapor diffusion and absorption; 2) packaging technology, including means for cooling components from cryogenic to high temperatures and reliability as affected by failure mechanisms such as dopant migration and intermetallic growth; and 3) peripheral equipment, including data storage in both magnetic and optical media and thermal issues in dot-matrix and thermal printer heads. The conference is being held in conjunction with the Electronics Components Conference (May 9-11) at the same site. [Contact: Frank F. Oettinger, (301) 975-2054]

Planned

Early summer (Vail, CO)

Combined Short Course on Optical Fiber and Laser Measurements. [Contact: Aaron A. Sanders, (303) 497-5341]

Early fall (Boulder, CO)

Fiber Optics Symposium. [Contact: Aaron A. Sanders, (303) 497-5341]

Late fall (Boulder, CO)

Symposium on Optical Materials for High Power Lasers (20th Boulder Damage Symposium). [Contact: Aaron A. Sanders, (303) 497-5341]

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All technical information included in this document has been previously approved for publication.

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

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This is the thirteenth issue of a quarterly publication providing information on the technical work of the National Bureau of Standards Center for Electronics and Electrical Engineering. This issue of the Center for Electronics and Electrical Engineering Technical Publication Announcements covers the second quarter of calendar year 1987. Abstracts are provided by technical area for papers published this quarter.

12. KEY WORDS *(Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)*

antennas; electrical engineering; electrical power; electromagnetic interference; electronics; instrumentation; laser; magnetics; microwave; optical fibers; semiconductors; superconductors

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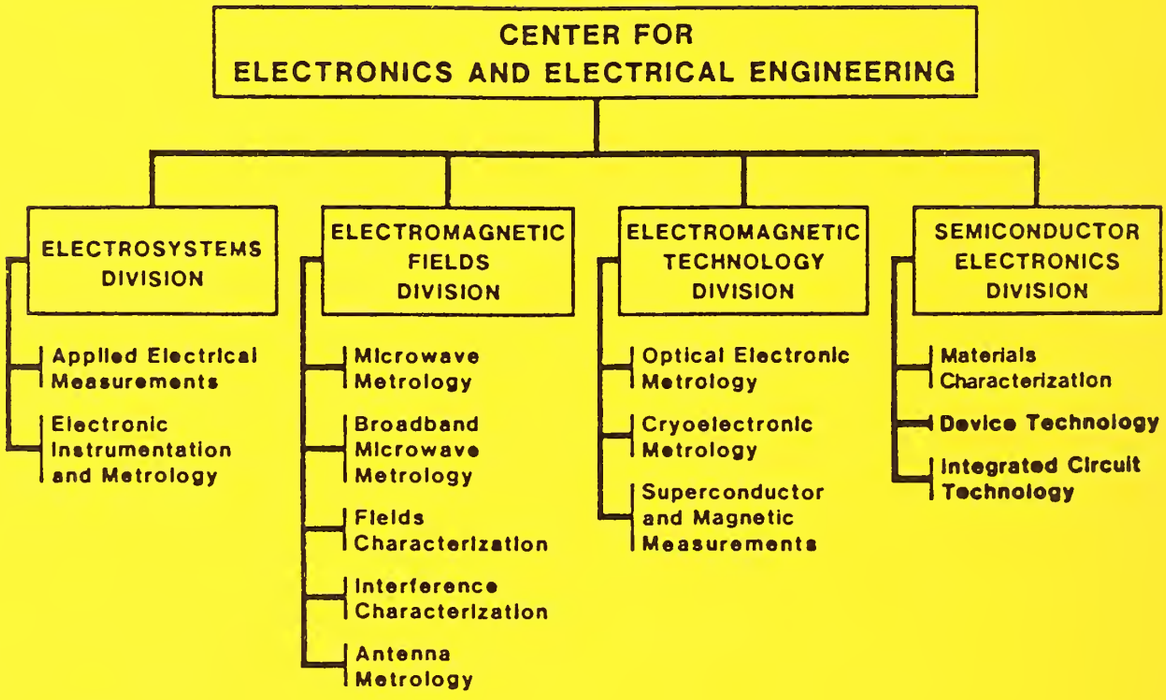

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